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(71)Applicant : SHARP CORP

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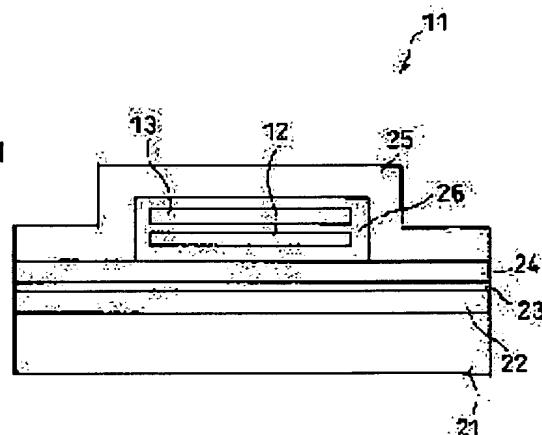
(72)Inventor : NAMIKATA RYOJI  
MICHIJIMA MASASHI  
HAYASHI HIDEKAZU

## (54) MAGNETIC MEMORY CELL AND MAGNETIC MEMORY DEVICE

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a magnetic memory cell which is formed by introducing a closed magnetic path structure into a ferromagnetic layer which is a memory layer and a magnetic memory device which retains cell density without degradation by using the magnetic memory cell.

**SOLUTION:** The magnetic memory cell 11 has an antiferromagnetic layer 21, a ferromagnetic layer 22 which is disposed on the antiferromagnetic layer 21, exhibits intra-surface magnetization and makes exchange bonding with the antiferromagnetic layer 21, an insulating layer 23 which is disposed on the ferromagnetic layer 22, a ferromagnetic layer 24 which is disposed on the insulating layer 23 and exhibits the intra-surface magnetization and a closed magnetic path layer 25 which is disposed on the ferromagnetic layer 24 and forms a closed magnetic path together with the ferromagnetic layer 24. The magnetic memory device is embodied by arranging such magnetic memory cells 11 to a grid form or zigzag form.



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**CLAIMS**

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[Claim(s)]

[Claim 1] The magnetic memory cell equipped with the 1st a little more than magnetic layer by which the sense of magnetization was substantially fixed to field inboard, the insulating layer prepared on the above-mentioned 1st a little more than magnetic layer, the 2nd a little more than magnetic layer which is prepared on the above-mentioned insulating layer and shows the magnetization within a field, and the closed magnetic circuit layer which is prepared on the above-mentioned 2nd a little more than magnetic layer, and forms a closed magnetic circuit with this 2nd a little more than magnetic layer.

[Claim 2] the center which is the space which the above-mentioned closed magnetic circuit layer was prepared on the above-mentioned 2nd a little more than magnetic layer so that it might estrange in the center section, and was made by alienation -- alienation -- the magnetic memory cell according to claim 1 characterized by being prepared so that the bit line and word line with which the section was insulated mutually may penetrate.

[Claim 3] The magnetic memory cell according to claim 2 characterized by preparing the metal layer further between the above-mentioned closed magnetic circuit layer and the above-mentioned 2nd a little more than magnetic layer.

[Claim 4] the center of each of two or more magnetic memory cells allotted to the train with each same word line while having arranged two or more magnetic memory cells according to claim 2 in the shape of an abbreviation grid -- alienation -- the center of each of two or more magnetic memory cells allotted to the line with each same bit line while wiring in the shape of a straight line so that the section might be penetrated -- alienation -- the magnetic memory apparatus characterized by a line writing direction bending and wiring so that the section may be penetrated.

[Claim 5] the center of each of two or more magnetic memory cells allotted to the line with each same word line while having arranged two or more magnetic memory cells according to claim 2 in the shape of an abbreviation grid -- alienation -- the center of each of two or more magnetic memory cells allotted to the train with each same bit line while wiring in the shape of a straight line so that the section might be penetrated -- alienation -- the magnetic memory apparatus characterized by bending and wiring in the direction of a train so that the section may be penetrated.

[Claim 6] While arranging alternately two or more magnetic memory cells according to claim 3 in an adjacent train or an adjacent line, each word line the center of each of the magnetic memory cell which was installed stair-like and allotted in this installation direction -- alienation -- each bit line, while wiring so that the section may be penetrated the center of each of the magnetic memory cell which was installed in the above-mentioned installation direction of each above-mentioned word line, and the direction which intersects perpendicularly stair-like, and was allotted in this installation direction -- alienation -- the magnetic memory apparatus characterized by wiring so that the section may be penetrated.

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[Translation done.]

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the magnetic memory cell which can reduce the effect of an anti-field by the magnetic pole of the both ends of a ferromagnetic layer, and the magnetic memory apparatus which has arranged two or more magnetic memory cells, without reducing a cell consistency.

[0002]

[Description of the Prior Art] In recent years, since a big output is obtained compared with a conventional anisotropy magneto-resistive effect (AMR) component and a conventional giant magneto-resistance (GMR) component, the magnetic tunnel junction (MTJ) component is considered in the application to the reproducing head for HDD, or magnetic memory.

[0003] It is useful that there is no danger that the content of record will disappear even if information's not being lost and the count of a repeat being infinity times even if it being the solid-state memory which does not have the operation section as well as semiconductor memory, and a power source are intercepted, and a radiation carry out incidence, in magnetic memory especially etc. as compared with semiconductor memory.

[0004] The example of a configuration of the conventional MTJ component 62 is shown in drawing 5. Such a MTJ component 62 of a configuration is shown in JP,9-106514,A.

[0005] The above-mentioned conventional MTJ component 62 carries out the laminating of the antiferromagnetism layer 51, the ferromagnetic layer 52, an insulating layer 53, and the ferromagnetic layer 54, as shown in drawing 5. Each magnetization of the ferromagnetic layer 52 and the ferromagnetic layer 54 is in a film surface, and it has effectual uniaxial magnetic anisotropy so that it may become parallel or anti-parallel. And it is substantially fixed to an one direction by switched connection with the antiferromagnetism layer 51, and magnetization of the ferromagnetic layer 52 holds record in the direction of magnetization of the ferromagnetic layer 54.

[0006] As an antiferromagnetism layer 51, alloys, such as FeMn, NiMn, MnPt, and MnIr, are used and Fe, Co, nickel, or these alloys are used as the ferromagnetic layer 52 and a ferromagnetic layer 54. Moreover, as an insulating layer 53, although various kinds of oxides and nitrides are examined, it is aluminum 2O3. It is known that the highest magnetic-reluctance (MR) ratio will be obtained in the case of the film. Moreover, in addition to this, the proposal of the MTJ component using the coercive force difference of the ferromagnetic layer 52 and the ferromagnetic layer 54 is also made with the configuration except the antiferromagnetism layer 51.

[0007] The schematic diagram at the time of using the MTJ component 62 of the structure of drawing 5 for the magnetic memory in which random access is possible is shown in drawing 6. The transistor 61 has the role which reads and sometimes chooses the MTJ component 62. "0" or "1" information is recorded by the sense of magnetization of the ferromagnetic layer 54 of the MTJ component 62 shown in drawing 5, and the sense of magnetization of the ferromagnetic layer 52 is being fixed. And when magnetization of the ferromagnetic layer 52 and the ferromagnetic layer 54 is parallel, resistance is low, and when it is anti-parallel, information is read using the magneto-resistive effect that resistance becomes high. Writing is realized by reversing the sense of magnetization of the ferromagnetic layer 54 by the synthetic field which a bit line 63 and a word line 64 form.

[0008]

[Problem(s) to be Solved by the Invention] By the way, with the MTJ component 62 of the above-mentioned configuration, since magnetization of the ferromagnetic layer 52 and the ferromagnetic layer 54 is field inboard, a magnetic pole is generated in both ends. Although it is necessary to make the MTJ component 62 detailed to

attain densification of magnetic memory, the effect of an anti-field by the magnetic pole of both ends becomes large with detailed-izing of a component. Thereby, the cel consistency of a magnetic memory cell will fall. [0009] Since switched connection is carried out to the antiferromagnetism layer 51 about the ferromagnetic layer 52, there is little above-mentioned effect of an anti-field, and it can make zero substantially the magnetic pole generated at the edge by constituting the ferromagnetic layer 52 from two ferromagnetic layers which carry out antiferromagnetism association as indicated by for example, the U.S. Pat. No. 5841692 number official report.

[0010] On the other hand, since the same technique cannot be used about the ferromagnetic layer 54 used as a memory layer, magnetization will become instability under the effect of an edge magnetic pole as a pattern makes it detailed, and maintenance of record will be difficult.

[0011] Then, it is possible by making the ferromagnetic layer 54 used as a memory layer into closed magnetic circuit structure to reduce the effect of an edge magnetic pole. Although the configuration which passes a bit line and a word line both along the inside of this closed magnetic circuit, then the effectiveness which can reverse magnetization of the ferromagnetic layer 54 efficiently at the time of writing are acquired at this time, it becomes difficult for a bit line and a word line to take an easy orthogonal array as shown in drawing 6 . In addition, in drawing 6 , a reference mark 65 shows a plate line.

[0012] The example of closed magnetic circuit structure is indicated by JP,10-302456,A etc. According to this, in the magnetic memory thin film memory device, the laminating of the 1st and 2nd magnetic layers which have the magnetization direction in the one direction in a film surface is carried out through the non-magnetic layer, and the 3rd magnetic layer is prepared in the side face of the 1st and 2nd magnetic layers, and it is arranged so that the 1st thru/or the 3rd magnetic layer may surround a non-magnetic layer as a whole. The external magnetic fields of magnetization of the 1st magnetic layer and magnetization of the 2nd magnetic layer are anti-parallel in the state of preservation of zero, and a closed magnetic circuit is formed through the 3rd magnetic layer.

[0013] According to the above-mentioned magnetic memory thin film memory device, in order that the magnetic film in connection with record may form a closed magnetic circuit at the time of preservation, the adverse effect by the anti-field can be avoided and it becomes possible to make small the cell size which is 1 bit. So, magnetic-thin-film memory with a high degree of integration is realizable.

[0014] however, with the conventional technique of a publication, to JP,10-302456,A Since it is the configuration of preparing the 3rd magnetic layer (closed magnetic circuit layer) in the side face of two ferromagnetic layers (the 1st and 2nd magnetic layers) Complicated processing [ become / make width of face of an insulating layer (non-magnetic layer) narrower than the 1st and 2nd magnetic layers for the 3rd magnetic layer, or / the same flat surface as each end face of the 1st and 2nd magnetic layers ] in which it is as processing the ends side and die length of the 3rd magnetic layer \*\*\*\* is needed. That is, with this conventional technique, since the above complicated processings are required, the magnetic memory cell excellent in productivity is unrealizable. And about the magnetic memory apparatus which arranges a magnetic memory cell the optimal, neither disclosure nor a suggestion is in JP,10-302456,A, without reducing a cel consistency.

[0015] Then, this invention is made in view of the above-mentioned trouble, and the object is in offering the magnetic memory apparatus to which a cel consistency does not fall using the magnetic memory cell which introduced closed magnetic circuit structure into the ferromagnetic layer used as a memory layer, and this magnetic memory cell.

[0016]

[Means for Solving the Problem] The 1st a little more than magnetic layer by which the sense of magnetization was substantially fixed to field inboard in order that the magnetic memory cell concerning this invention might solve the above-mentioned technical problem, It has the insulating layer prepared on the above-mentioned 1st a little more than magnetic layer, the 2nd a little more than magnetic layer which is prepared on the above-mentioned insulating layer and shows the magnetization within a field, and the closed magnetic circuit layer which is prepared on the above-mentioned 2nd a little more than magnetic layer, and forms a closed magnetic circuit with this 2nd a little more than magnetic layer.

[0017] According to the above-mentioned invention, it is not the configuration of preparing the 3rd magnetic layer (closed magnetic circuit layer) in the side face of two ferromagnetic layers (the 1st and 2nd magnetic layers) like the conventional technique given in JP,10-302456,A. Since it is the configuration that a closed magnetic circuit layer is prepared on the 2nd ferromagnetism, the dimension of the cross direction of a magnetic

memory cell does not increase. And complicated processing [ become / make width of face of an insulating layer (non-magnetic layer) narrower than the 1st and 2nd magnetic layers for the 3rd magnetic layer, or / the same flat surface as each end face of the 1st and 2nd magnetic layers ] in which it is as processing the ends side and die length of the 3rd magnetic layer \*\*\*\* becomes unnecessary.

[0018] That is, according to the above-mentioned invention, since complicated processing like before is unnecessary while being able to make small area (1-bit cell size) which a magnetic memory cell occupies with the easy configuration of preparing a closed magnetic circuit layer on the 2nd ferromagnetism, the magnetic memory cell excellent in productivity is realizable.

[0019] In this magnetic memory cell, a magnetic tunnel junction component is formed of the 1st a little more than magnetic layer, an insulating layer, and the 2nd a little more than magnetic layer. According to change of the magnitude of an external magnetic field, the spin of the 1st and the 2nd a little more than magnetic layer changes to anti-parallel and parallel, and a magnetic tunnel junction component shows the phenomenon in which tunnel conductance changes, with this change. Storage is realizable if this phenomenon is used.

[0020] Since the sense of magnetization is being substantially fixed to field inboard, the clear switching of the anti-parallel of spin and parallel of the 1st a little more than magnetic layer is attained. That is, since the spin of the 1st a little more than magnetic layer is being fixed and the spin of the 2nd a little more than magnetic layer can be moved according to an external magnetic field, parallel of spin and anti-parallel can be performed clearly. While "0" or "1" information is recorded by the sense of magnetization of the 2nd a little more than magnetic layer, the sense of magnetization of the 1st a little more than magnetic layer is being fixed by the above-mentioned switching. And when magnetization of the 1st and the 2nd a little more than magnetic layer is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high.

[0021] Since the above-mentioned closed magnetic circuit layer forms a closed magnetic circuit with the 2nd a little more than magnetic layer, it can make zero substantially the magnetic pole generated to the both ends of the 2nd a little more than magnetic layer. Thereby, generating of an anti-field which originates in this magnetic pole and is produced can be reduced certainly. Thus, since the effect of an anti-field by the magnetic pole of the both ends of the 2nd a little more than magnetic layer is avoidable, magnetization of the 2nd a little more than magnetic layer is stabilized, and, thereby, -izing of the magnetic memory cell can be carried out [ detailed ]. And since the 2nd a little more than magnetic layer forms the closed magnetic circuit with the closed magnetic circuit layer, stabilization can be attained to an external leakage field.

[0022] the center which is the space which the above-mentioned closed magnetic circuit layer was prepared on the above-mentioned 2nd a little more than magnetic layer so that it might estrange in the center section, and was made by alienation -- alienation -- it is desirable to be prepared so that the bit line and word line with which the section was insulated mutually may penetrate.

[0023] In this case, since the both sides of a bit line and a word line become a configuration passing through the inside of a closed magnetic circuit, magnetization of the 2nd a little more than magnetic layer can be efficiently reversed at the time of writing.

[0024] the center of each of two or more magnetic memory cells allotted to the train (or the same line) with each same word line while having arranged two or more above-mentioned magnetic memory cells in the shape of an abbreviation grid -- alienation -- the center of each of two or more magnetic memory cells allotted to the line (or the same train) with each same bit line while wiring in the shape of a straight line so that the section might be penetrated -- alienation -- it is desirable that a line writing direction (or the direction of a train) bends and wires so that the section may be penetrated.

[0025] In this case, since the magnetic memory cell by which the effect of an anti-field by the magnetic pole of the both ends of the 1st and the 2nd a little more than magnetic layer was reduced is used, two or more magnetic memory cells can be arranged in a high cel consistency in the shape of an abbreviation grid. If width of face of wiring is set to F by wiring each word line and each bit line as mentioned above, respectively, while the minimum period of a word line will be set to 2F (or 4F), the minimum period of a bit line is set to 4F (or 2F).

[0026] According to this magnetic memory apparatus, "0" or "1" information is recorded by the sense of magnetization of the 2nd a little more than magnetic layer. At this time, the sense of magnetization of the 1st a little more than magnetic layer is being fixed. And when magnetization of the 1st and the 2nd a little more than magnetic layer is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information

is carried out using the magneto-resistive effect that resistance becomes high. Informational writing is realized by reversing the sense of magnetization of the 2nd a little more than magnetic layer by the synthetic field in which the flowing current forms a bit line and a word line.

[0027] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the 1st and the 2nd a little more than magnetic layer of a magnetic memory cell can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of a magnetic memory cell was made detailed according to the above-mentioned magnetic memory apparatus, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the 2nd a little more than magnetic layer used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer, while becoming stability to an external leakage field, it is also possible to reduce the power consumption of the magnetic memory apparatus which used many such magnetic memory cells.

[0028] It may replace with the above-mentioned magnetic memory cell, and that by which the metal layer is further prepared between the above-mentioned closed magnetic circuit layer and the above-mentioned 2nd a little more than magnetic layer may be used. In this case, since structure where the interface of the 2nd a little more than magnetic layer / closed magnetic circuit layer does not exist is realized, it becomes possible to raise the yield of a magnetic memory cell.

[0029] While using two or more such magnetic memory cells and arranging alternately these two or more magnetic memory cells in an adjacent train or an adjacent line, each word line the center of each of the magnetic memory cell which was installed stair-like and allotted in this installation direction -- alienation -- each bit line, while wiring so that the section may be penetrated the center of each of the magnetic memory cell which was installed in the above-mentioned installation direction of each above-mentioned word line, and the direction which intersects perpendicularly stair-like, and was allotted in this installation direction -- alienation -- the magnetic memory apparatus wired so that the section might be penetrated may be constituted.

[0030] In this case, since the magnetic memory cell by which the effect of an anti-field by the magnetic pole of the both ends of the 1st and the 2nd a little more than magnetic layer was reduced is used, two or more magnetic memory cells can be arranged in a high cell consistency in the shape of an abbreviation grid. If width of face of wiring is set to  $F$  by wiring each word line and each bit line as mentioned above, respectively, both a bit line and a word line will have the minimum period of abbreviation  $2F$ , and the further high integration of them will be attained from the above-mentioned magnetic memory apparatus.

[0031] According to this magnetic memory apparatus, "0" or "1" information is recorded by the sense of magnetization of the 2nd a little more than magnetic layer. At this time, the sense of magnetization of the 1st a little more than magnetic layer is being fixed. And when magnetization of the 1st and the 2nd a little more than magnetic layer is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high. Informational writing is realized by reversing the sense of magnetization of the 2nd a little more than magnetic layer by the synthetic field in which the flowing current forms a bit line and a word line.

[0032] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the 1st and the 2nd a little more than magnetic layer of a magnetic memory cell can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of a magnetic memory cell was made detailed according to the above-mentioned magnetic memory apparatus, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the 2nd a little more than magnetic layer used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer, the 2nd a little more than magnetic layer can also reduce the power consumption of the magnetic memory apparatus which used many such magnetic memory cells while serving as stability to an external leakage field.

[0033]

[Embodiment of the Invention] It will be as follows if one gestalt of operation of this invention is explained based on drawing 1 R> 1 and drawing 2 .

[0034] The magnetic memory apparatus concerning the gestalt of this operation consists of two or more magnetic memory cells 11, as shown in drawing 2 R> 2. Each magnetic memory cell 11 has cross-section structure as shown in drawing 1 , and the closed magnetic circuit layer 25 is formed on the MTJ component which consists of the antiferromagnetism layer 21, the ferromagnetic layer 22, an insulating layer 23, and a

ferromagnetic layer 24.

[0035] The above-mentioned ferromagnetic layer 22 and the above-mentioned ferromagnetic layer 24 show the magnetization within a field (the sense of magnetization is field inboard). Each magnetization of the ferromagnetic layer 22 and the ferromagnetic layer 24 is in a film surface, and it has effectual uniaxial magnetic anisotropy so that it may become parallel or anti-parallel. And it is substantially fixed to an one direction by switched connection with the antiferromagnetism layer 21, and magnetization of the ferromagnetic layer 22 holds record in the direction of magnetization of the ferromagnetic layer 24.

[0036] As an antiferromagnetism layer 21, alloys, such as FeMn, NiMn, MnPt, and MnIr, are used and Fe, Co, nickel, or these alloys are used as the ferromagnetic layer 22 and a ferromagnetic layer 24. Moreover, as an insulating layer 23, although various kinds of oxides and nitrides are examined, it is aluminum 2O3. In the case of the film, the highest magnetic-reluctance (MR) ratio is obtained.

[0037] In the MTJ component of the above-mentioned configuration, since it is constituted so that the antiferromagnetism layer 21 and the ferromagnetic layer 22 may carry out switched connection, the effect of the magnetic pole generated to the both ends of the ferromagnetic layer 22 can be reduced. Moreover, since the closed magnetic circuit layer 25 is formed on the MTJ component of the above-mentioned configuration, the above-mentioned ferromagnetic layer 24 used as a memory layer will form a closed magnetic circuit with the above-mentioned closed magnetic circuit layer 25. Since the magnetic pole generated to the both ends of the ferromagnetic layer 24 can be substantially made into zero by this, the effect of this magnetic pole can be reduced.

[0038] According to change of the magnitude of an external magnetic field, the spin of two ferromagnetic layers 22 and 24 changes to anti-parallel and parallel, and the above-mentioned magnetic memory cell 11 shows the phenomenon in which tunnel conductance changes, with this change. Storage is realizable if this phenomenon is used. That is, if the ferromagnetic layer 22 uses the phenomenon in which the spin of the ferromagnetic layer 22 is fixed by the exchange field, by junction in the antiferromagnetism layer 21, the clear switching of the anti-parallel of spin and parallel of it will be attained.

[0039] If the spin of the above-mentioned ferromagnetic layer 22 is fixed, since the spin of the ferromagnetic layer 24 can be moved according to an external magnetic field, parallel of spin and anti-parallel can be performed clearly. While "0" or "1" information is recorded by the sense of magnetization of the ferromagnetic layer 24, the sense of magnetization of the ferromagnetic layer 22 is fixed by the above-mentioned switching. And when magnetization of the ferromagnetic layers 22 and 24 is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high.

[0040] the above-mentioned closed magnetic circuit layer 25 is formed by junction on the above-mentioned ferromagnetic layer 24 so that it may estrange in the center section (the space hereafter produced as a result of being estranged in the center section in this way -- a center -- alienation -- the section is called.). the center of the closed magnetic circuit layer 25 -- alienation -- a bit line 12 (let the above-mentioned reference mark 12a-12b be one bit line 12.) and a word line 13 (let the above-mentioned reference mark 13a-13b be one word line 13.) penetrate to the space perpendicular direction of drawing 1 through the section. Since the both sides of a bit line 12 and a word line 13 become a configuration passing through the inside of the closed magnetic circuit formed of the ferromagnetic layer 24 and the closed magnetic circuit layer 25 by this, magnetization of the ferromagnetic layer 24 can be efficiently reversed at the time of writing. in addition, the center of the above -- alienation -- the insulating layer 26 is formed in the section so that a bit line 12 and a word line 13 may be insulated electrically mutually.

[0041] Although it is necessary to make a MTJ component detailed to attain densification of a magnetic memory apparatus, the effect of an anti-field by the magnetic pole of the both ends of a ferromagnetic layer becomes large with detailed-izing of a MTJ component (magnetization of the ferromagnetic layer 24 becomes instability.). Thereby, the cel consistency of a magnetic memory cell was falling conventionally.

[0042] However, according to the magnetic memory apparatus concerning the gestalt of this operation, the anti-field by the magnetic pole of each both ends of the ferromagnetic layer 22 and the ferromagnetic layer 24 can be certainly reduced by constituting each magnetic memory cell 11 as mentioned above. Especially, since magnetization of the ferromagnetic layer 24 becomes stability, if two or more magnetic memory cells 11 which have the above-mentioned configuration are arranged appropriately, lowering of a cel consistency is certainly

avoidable [ with the reduction of an anti-field by the magnetic pole of the both ends of the ferromagnetic layer 24 ].

[0043] Here, it explains, referring to drawing 2 about the ability of two or more magnetic memory cells 11 which have the above-mentioned configuration to be arranged without reducing a cell consistency, if it carries out what. In addition, for simplification of drawing, a selection transistor omits drawing 2 and it is drawn.

[0044] According to the magnetic memory apparatus concerning the gestalt of this operation, as shown in drawing 2 , two or more magnetic memory cells 11 which have the above-mentioned configuration shown in drawing 1 are arranged in the shape of an abbreviation grid. In addition, in drawing 2 , the condition of having been arranged is drawn so that the antiferromagnetism layer 21 may turn [ the magnetic memory cell 11 of drawing 1 ] up and the closed magnetic circuit layer 25 may turn down.

[0045] the center of each of two or more magnetic memory cells 11 allotted to the same train as each word line 13 was shown in drawing 2 -- alienation -- it wires in the shape of a straight line in the vertical direction (namely, lengthwise direction) of a drawing so that the section may be penetrated. the center of each of two or more magnetic memory cells 11 allotted to the same line on the other hand as each bit line 12 was shown in drawing 2 -- alienation -- the longitudinal direction (namely, longitudinal direction) of a drawing bends and wires so that the section may be penetrated.

[0046] Since each word line 13 is formed in the vertical direction (namely, lengthwise direction) in the shape of a straight line, the same wiring as the conventional thing shown in drawing 5 is possible for it. magnetic memory cell 11 comrades allotted to the line with the longitudinal direction (namely, longitudinal direction) same [ a bit line 12 ] which are the above-mentioned word line 13 and the direction of a right angle on the other hand -- the center of each -- alienation -- since it is necessary to wire through the section, the longitudinal direction bends and wires by the upper and lower sides (upper and lower sides on the space of drawing 2 ) of each magnetic memory cell 11. Therefore, if width of face of wiring is set to F, while the minimum period of a word line 13 will be set to 2F, the minimum period of a bit line 12 is set to 4F.

[0047] When the magnetic memory cell 11 of the structure of drawing 1 is wired like drawing 2 and the magnetic memory apparatus in which random access is possible is constituted, "0" or "1" information is recorded by the sense of magnetization of the ferromagnetic layer 24. The sense of magnetization of the ferromagnetic layer 22 is being fixed at this time. And when magnetization of the ferromagnetic layer 22 and the ferromagnetic layer 24 is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high. Informational writing is realized by reversing the sense of magnetization of the ferromagnetic layer 24 by the synthetic field which a bit line 12 and a word line 13 form.

[0048] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the ferromagnetic layers 22 and 24 of the magnetic memory cell 11 can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of the magnetic memory cell 11 was made detailed according to the magnetic memory apparatus of the gestalt of this operation, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the ferromagnetic layer 24 used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer 25, the ferromagnetic layer 24 can also reduce the power consumption of the magnetic memory apparatus which used a majority of such magnetic memory cells 11 while serving as stability to an external leakage field.

[0049] The above-mentioned magnetic memory apparatus is not limited to arrangement of the magnetic memory cell 11 shown in drawing 2 , and it should just bend and arrange another side while it arranges either the bit line which penetrates the closed magnetic circuit of this magnetic memory cell while the magnetic layer which holds storage at least arranges the magnetic memory cell which has closed magnetic circuit structure in the shape of an abbreviation grid, or a word line in the shape of a straight line. therefore, the center of each of two or more magnetic memory cells 11 where each bit line 12 was allotted to the same train -- alienation -- so that the section may be penetrated the center of each of two or more magnetic memory cells 11 where each load line 13 was allotted to the same line while wiring in the shape of a straight line in the vertical direction (namely, lengthwise direction) of a drawing -- alienation -- arrangement which is bent and wired by the longitudinal direction (namely, longitudinal direction) of a drawing is sufficient so that the section may be penetrated.

[0050] It explains referring to drawing 3 and drawing 4 about other magnetic memory apparatus which start the



gestalt of this operation here.

[0051] The magnetic memory apparatus concerning the gestalt of other operations of this invention is shown in drawing 4. This magnetic memory apparatus consists of two or more magnetic memory cells 31, as shown in drawing 4. Each magnetic memory cell 31 has cross-section structure as shown in drawing 3, and the closed magnetic circuit layer 45 is formed through the thin metal layer 47 on the MTJ component which consists of the antiferromagnetism layer 41, the ferromagnetic layer 42, an insulating layer 43, and a ferromagnetic layer 44.

[0052] The above-mentioned ferromagnetic layer 42 and the above-mentioned ferromagnetic layer 44 show the magnetization within a field (the sense of magnetization is field inboard). The above-mentioned ferromagnetic layer 42 and the above-mentioned ferromagnetic layer 44 show the magnetization within a field (the sense of magnetization is field inboard). Each magnetization of the ferromagnetic layer 42 and the ferromagnetic layer 44 is in a film surface, and it has effectual uniaxial magnetic anisotropy so that it may become parallel or anti-parallel. And it is substantially fixed to an one direction by switched connection with the antiferromagnetism layer 41, and magnetization of the ferromagnetic layer 42 holds record in the direction of magnetization of the ferromagnetic layer 44.

[0053] As an antiferromagnetism layer 41, alloys, such as FeMn, NiMn, MnPt, and MnIr, are used and Fe, Co, nickel, or these alloys are used as the ferromagnetic layer 42 and a ferromagnetic layer 44. Moreover, as an insulating layer 43, although various kinds of oxides and nitrides are examined, it is aluminum 2O3. In the case of the film, the highest magnetic-reluctance (MR) ratio is obtained.

[0054] In the MTJ component of the above-mentioned configuration, since it is constituted so that the antiferromagnetism layer 41 and the ferromagnetic layer 42 may carry out switched connection, the effect of the magnetic pole generated to the both ends of the ferromagnetic layer 42 can be reduced.

[0055] The ferromagnetic layer 44 and the closed magnetic circuit layer 45 are carrying out diamagnetism association through the metal layer 47 at both ends. By this, the above-mentioned ferromagnetic layer 44 used as a memory layer will form a closed magnetic circuit with the above-mentioned closed magnetic circuit layer 45 through the metal layer 47. So, since the magnetic pole generated to the both ends of the ferromagnetic layer 44 can be substantially made into zero, the effect of this magnetic pole can be reduced. And since structure where the interface of the 44/closed magnetic circuit layer 45 of ferromagnetic layers does not exist as mentioned above since the metal layer 47 is formed between the ferromagnetic layer 44 and the closed magnetic circuit layer 45 is realized, it becomes possible to raise the yield of the magnetic memory cell 31.

[0056] According to change of the magnitude of an external magnetic field, the spin of two ferromagnetic layers 42 and 44 changes to anti-parallel and parallel, and the above-mentioned magnetic memory cell 31 shows the phenomenon in which tunnel conductance changes, with this change. Storage is realizable if this phenomenon is used. That is, if the ferromagnetic layer 42 uses the phenomenon in which the spin of the ferromagnetic layer 42 is fixed by the exchange field, by junction in the antiferromagnetism layer 41, the clear switching of the anti-parallel of spin and parallel of it will be attained. If the spin of the ferromagnetic layer 42 is fixed, since the spin of the ferromagnetic layer 44 can be moved according to an external magnetic field, parallel of spin and anti-parallel can be performed clearly. While "0" or "1" information is recorded by the sense of magnetization of the ferromagnetic layer 44, the sense of magnetization of the ferromagnetic layer 42 is being fixed by the above-mentioned switching. And when magnetization of the ferromagnetic layers 42 and 44 is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high.

[0057] the above-mentioned closed magnetic circuit layer 45 is formed through the metal layer 47 on the above-mentioned ferromagnetic layer 44 so that it may estrange in the center section (the space hereafter produced as a result of being estranged in the center section in this way -- a center -- alienation -- the section is called.). the center of the closed magnetic circuit layer 45 -- alienation -- a bit line 32 (let the above-mentioned reference mark 32a-32b be one bit line 32.) and a word line 33 (let the above-mentioned reference mark 33a-33b be one word line 33.) penetrate to the space perpendicular direction of drawing 3 through the section.

[0058] Since the both sides of a bit line 32 and a word line 33 become a configuration passing through the inside of the closed magnetic circuit formed of the ferromagnetic layer 44 and the closed magnetic circuit layer 45 by this, magnetization of the ferromagnetic layer 44 can be efficiently reversed at the time of writing. in addition, the center of the above -- alienation -- the insulating layer 46 is formed in the section so that a bit line 32 and a word line 33 may be insulated electrically mutually.

[0059] Although it is necessary to make a MTJ component detailed to attain densification of a magnetic memory apparatus, the effect of an anti-field by the magnetic pole of the both ends of a ferromagnetic layer becomes large with detailed-izing of a MTJ component (magnetization of the ferromagnetic layer 44 becomes instability.). Thereby, the cel consistency of a magnetic memory cell was falling conventionally.

[0060] However, according to the magnetic memory apparatus concerning the gestalt of this operation, the anti-field by the magnetic pole of each both ends of the ferromagnetic layer 42 and the ferromagnetic layer 44 can be certainly reduced by constituting each magnetic memory cell 31 as mentioned above. Especially, since magnetization of the ferromagnetic layer 44 becomes stability, if two or more magnetic memory cells 31 which have the above-mentioned configuration are arranged appropriately, lowering of a cel consistency is certainly avoidable [ with the reduction of an anti-field by the magnetic pole of the both ends of the ferromagnetic layer 44 / magnetization of the ferromagnetic layer 44 becomes stability, and ].

[0061] Here, it explains, referring to drawing 4 about the ability of two or more magnetic memory cells 31 which have the above-mentioned configuration to be arranged without reducing a cel consistency, if it carries out what. In addition, for simplification of drawing, a selection transistor omits drawing 4 and it is drawn.

[0062] two or more magnetic memory cells 31 which according to the magnetic memory apparatus concerning the gestalt of this operation have the above-mentioned configuration shown in drawing 3 as shown in drawing 4 -- being alternate (the shape of an abbreviation rhombus) -- it is arranged. That is, two or more magnetic memory cells 31 allotted to an adjacent train or an adjacent line are arranged alternately. In addition, in drawing 4 , the condition of having been arranged is drawn so that the antiferromagnetism layer 41 may turn [ the magnetic memory cell 31 of drawing 3 ] up and the closed magnetic circuit layer 45 may turn down.

[0063] the center of each of the magnetic memory cell 31 which was installed stair-like and allotted in this installation direction as each word line 33 (let reference mark 33a-33b be one word line 33.) was shown in drawing 4 -- alienation -- it wires so that the section may be penetrated. the center of each of the magnetic memory cell 31 which was installed in the installation direction of each above-mentioned word line 33, and the direction which intersects perpendicularly stair-like, and was allotted in this installation direction on the other hand as each bit line 32 (let reference mark 32a-32b be one bit line 32.) was shown in drawing 4 -- alienation -- it wires so that the section may be penetrated.

[0064] two or more magnetic memory cells 31 matched for the position with each word line 33 and each bit line 32 by each -- the center of each -- alienation -- since it is necessary to wire stair-like through the section, the longitudinal direction bends and wires by the upper and lower sides (upper and lower sides on the space of drawing 4 ) of each magnetic memory cell 31. Therefore, if width of face of wiring is set to F, both a bit line 32 and the word line 33 will have the minimum period of abbreviation 2F, and the further high integration of them will be attained from the magnetic memory apparatus of drawing 2 .

[0065] When the magnetic memory cell 31 of the structure of drawing 3 is wired like drawing 4 and the magnetic memory apparatus in which random access is possible is constituted, "0" or "1" information is recorded by the sense of magnetization of the ferromagnetic layer 44. The sense of magnetization of the ferromagnetic layer 42 is being fixed at this time. And when magnetization of the ferromagnetic layer 42 and the ferromagnetic layer 44 is parallel, resistance is low, and when it is anti-parallel, reading appearance of the information is carried out using the magneto-resistive effect that resistance becomes high. Informational writing is realized by reversing the sense of magnetization of the ferromagnetic layer 44 by the synthetic field which a bit line 32 and a word line 33 form.

[0066] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the ferromagnetic layers 42 and 44 of the magnetic memory cell 31 can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of the magnetic memory cell 31 was made detailed according to the magnetic memory apparatus of the gestalt of this operation, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the ferromagnetic layer 44 used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer 45, the ferromagnetic layer 44 can also reduce the power consumption of the magnetic memory apparatus which used a majority of such magnetic memory cells 31 while serving as stability to an external leakage field.

[0067] The above-mentioned magnetic memory apparatus is not limited to arrangement of the magnetic memory cell 31 shown in drawing 4 , and it should just wire the bit line and word line which penetrate the

closed magnetic circuit of this magnetic memory cell in the direction of slant (for example, the 45 abbreviation direction) to the direction of a closed magnetic circuit of this magnetic memory cell while the magnetic layer which holds storage at least arranges the magnetic memory cell which has closed magnetic circuit structure to an abbreviation rhombus (alternate).

[0068] Although it is not limited especially if the above-mentioned closed magnetic circuit layers 25 and 45 have coercive force smaller than the ferromagnetic layers 22 and 42 which memorize information at least, what has high permeability is desirable. As an ingredient which has such a property, for example, the NiFe film, the FeAlSi film, the CoZrNb amorphous film, etc. are mentioned.

[0069] In addition, although the bit line 12 and the word line 13 are drawn in drawing 2 for convenience so that the width of face of wiring may differ mutually in order to make it legible, it has the width of face of abbreviation identitas actually. Although similarly the bit line 32 and the word line 33 are drawn in drawing 4 R> 4 for convenience so that the width of face of wiring may differ mutually in order to make it legible, it has the width of face of abbreviation identitas actually.

[0070] Moreover, although the above explains the example in which an antiferromagnetism layer and the 1st a little more than magnetic layer (the antiferromagnetism layer 21, the ferromagnetic layer 22, or the antiferromagnetism layer 41 and the ferromagnetic layer 42) carry out switched connection, the two-layer magnetic layer of this invention which is not limited to this and carries out antiferromagnetism association through the big magnetic layer of coercive force and a thin metal layer is usable. That is, in this invention, if the sense of magnetization is fixed substantially [ the 1st a little more than magnetic layer ] in field inboard, especially a configuration will not be limited.

[0071] Although the above explanation showed two examples using the TMR component as a magnetic memory cell which has closed magnetic circuit structure, it is also possible to use the magnetic memory cell which has other closed magnetic circuit structures. Moreover, in this invention, it is not limited to the example mentioned above about direction of a bit line, a word line, and closed magnetic circuit structure.

[0072] The 1st MAG memory apparatus of this invention is characterized by bending and arranging another side while it arranges either the bit line which penetrates the closed magnetic circuit of this magnetic memory cell while the magnetic layer which holds storage at least arranges the magnetic memory cell which has closed magnetic circuit structure in the shape of an abbreviation grid as mentioned above, or a word line in the shape of a straight line.

[0073] The 2nd MAG memory apparatus of this invention is characterized by wiring 45 abbreviation hard flow to the direction of a closed magnetic circuit of this magnetic memory cell in the bit line and word line which penetrate the closed magnetic circuit of this magnetic memory cell while it arranges the magnetic memory cell in which the magnetic layer which holds storage at least has closed magnetic circuit structure so that it may become an abbreviation rhombus.

[0074] The 3rd MAG memory apparatus of this invention is set to the above-mentioned 1st or 2nd MAG memory apparatus. The above-mentioned magnetic memory cell consists of a magnetic tunnel junction component which carried out the laminating of the 1st magnetic layer, an insulating layer, and the 2nd magnetic layer to order at least. And at least, a center section is estranged, the 3rd magnetic layer is prepared in a side which is [ this insulating regular placing being / of the 1st or 2nd magnetic layer of the above / a layer, and ] different, and it is characterized by the closed magnetic circuit being constituted by the 1st and 3rd magnetic layers of the above, or the 2nd and 3rd magnetic layers of the above.

[0075] The 4th MAG memory apparatus of this invention is set to the above-mentioned 1st or 2nd MAG memory apparatus. The above-mentioned magnetic memory cell consists of a magnetic tunnel junction component which carried out the laminating of the 1st magnetic layer, an insulating layer, and the 2nd magnetic layer to order at least. And it is characterized by estranging a center section through a metal layer, preparing the 3rd magnetic layer, and the closed magnetic circuit being constituted at least, by the 1st and 3rd magnetic layers of the above, or the 2nd and 3rd magnetic layers of the above at a side which is [ this insulating regular placing being / of the 1st or 2nd magnetic layer of the above / a layer, and ] different.

[0076] Since the effect of the magnetic pole of the both ends of a magnetic memory cell can be reduced, while being able to hold the magnetization condition stabilized even if the pattern was made detailed according to the above-mentioned 1st thru/or the above-mentioned 4th MAG memory apparatus, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the ferromagnetic

layer used as a memory layer takes closed magnetic circuit structure, this ferromagnetic layer can reduce the power consumption of the magnetic memory apparatus which used many such magnetic memory cells while serving as stability to an external leakage field.

[0077]

[Effect of the Invention] The magnetic memory cell concerning this invention is equipped with the 1st a little more than magnetic layer by which the sense of magnetization was substantially fixed to field inboard, the insulating layer prepared on the above-mentioned 1st a little more than magnetic layer, the 2nd a little more than magnetic layer which is prepared on the above-mentioned insulating layer and shows the magnetization within a field, and the closed magnetic circuit layer which is prepared on the above-mentioned 2nd a little more than magnetic layer, and forms a closed magnetic circuit with this 2nd a little more than magnetic layer as mentioned above.

[0078] Since it is not the configuration that prepares the 3rd magnetic layer in the side face of two ferromagnetic layers like the conventional technique given in JP,10-302456,A but the configuration that a closed magnetic circuit layer is prepared on the 2nd ferromagnetism according to the above-mentioned invention Complicated processing [ become / the dimension of the cross direction of a magnetic memory cell does not increase, and / make width of face of an insulating layer narrower than the 1st and the 2nd a little more than magnetic layer for the 3rd magnetic layer, or / dimension / the same flat surface as each end face of the 1st and the 2nd a little more than magnetic layer ] in which it is as processing the ends side and die length of the 3rd magnetic layer \*\*\*\* becomes unnecessary.

[0079] That is, while being able to make small area (1-bit cell size) which a magnetic memory cell occupies with the easy configuration of preparing a closed magnetic circuit layer on the 2nd ferromagnetism, since complicated processing like before is unnecessary, the magnetic memory cell excellent in productivity is realizable according to the above-mentioned invention.

[0080] Since the above-mentioned closed magnetic circuit layer forms a closed magnetic circuit with the 2nd a little more than magnetic layer, it can make zero substantially the magnetic pole generated to the both ends of the 2nd a little more than magnetic layer. Thereby, generating of an anti-field which originates in this magnetic pole and is produced can be reduced certainly. Thus, since the effect of an anti-field by the magnetic pole of the both ends of the 2nd a little more than magnetic layer is avoidable, magnetization of the 2nd a little more than magnetic layer is stabilized, and, thereby,-izing of the magnetic memory cell can be carried out [ detailed ]. And since the effect of an anti-field which can attain stabilization to an external leakage field since the 2nd a little more than magnetic layer forms the closed magnetic circuit with the closed magnetic circuit layer according as mentioned above to the magnetic pole of the both ends of the 2nd a little more than magnetic layer is avoidable, magnetization of the 2nd a little more than magnetic layer is stabilized, and, thereby,-izing of the magnetic memory cell can be carried out [ detailed ]. And since the 2nd a little more than magnetic layer forms the closed magnetic circuit with the closed magnetic circuit layer, the effectiveness that stabilization can be attained to an external leakage field is collectively done so.

[0081] the center which is the space which the above-mentioned closed magnetic circuit layer was prepared on the above-mentioned 2nd a little more than magnetic layer so that it might estrange in the center section, and was made by alienation -- alienation -- it is desirable to be prepared so that the bit line and word line with which the section was insulated mutually may penetrate.

[0082] In this case, since the both sides of a bit line and a word line become a configuration passing through the inside of a closed magnetic circuit, magnetization of the 2nd a little more than magnetic layer can be efficiently reversed at the time of writing.

[0083] the center of each of two or more magnetic memory cells allotted to the train (or the same line) with each same word line while having arranged two or more above-mentioned magnetic memory cells in the shape of an abbreviation grid -- alienation -- the center of each of two or more magnetic memory cells allotted to the line (or the same train) with each same bit line while wiring in the shape of a straight line so that the section might be penetrated -- alienation -- it is desirable that a line writing direction (or the direction of a train) bends and wires so that the section may be penetrated.

[0084] In this case, since the magnetic memory cell by which the effect of an anti-field by the magnetic pole of the both ends of the 1st and the 2nd a little more than magnetic layer was reduced is used, two or more magnetic memory cells can be arranged in a high cel consistency in the shape of an abbreviation grid. If width of face of

wiring is set to F by wiring each word line and each bit line as mentioned above, respectively, while the minimum period of a word line will be set to 2F (or 4F), the minimum period of a bit line is set to 4F (or 2F). [0085] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the 1st and the 2nd a little more than magnetic layer of a magnetic memory cell can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of a magnetic memory cell was made detailed according to the above-mentioned magnetic memory apparatus, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the 2nd a little more than magnetic layer used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer, while becoming stability to an external leakage field, reducing the power consumption of the magnetic memory apparatus which used many such magnetic memory cells also does so collectively the effectiveness of being possible.

[0086] It may replace with the above-mentioned magnetic memory cell, and that by which the metal layer is further prepared between the above-mentioned closed magnetic circuit layer and the above-mentioned 2nd a little more than magnetic layer may be used. In this case, since structure where the interface of the 2nd a little more than magnetic layer / closed magnetic circuit layer does not exist is realized, the effectiveness of becoming possible to raise the yield of a magnetic memory cell is collectively done so.

[0087] While using two or more such magnetic memory cells and arranging alternately these two or more magnetic memory cells in an adjacent train or an adjacent line, each word line the center of each of the magnetic memory cell which was installed stair-like and allotted in this installation direction -- alienation -- each bit line, while wiring so that the section may be penetrated the center of each of the magnetic memory cell which was installed in the above-mentioned installation direction of each above-mentioned word line, and the direction which intersects perpendicularly stair-like, and was allotted in this installation direction -- alienation -- the magnetic memory apparatus wired so that the section might be penetrated may be constituted.

[0088] In this case, since the magnetic memory cell by which the effect of an anti-field by the magnetic pole of the both ends of the 1st and the 2nd a little more than magnetic layer was reduced is used, two or more magnetic memory cells can be arranged in a high cel consistency in the shape of an abbreviation grid. If width of face of wiring is set to F by wiring each word line and each bit line as mentioned above, respectively, both a bit line and a word line will have the minimum period of abbreviation 2F, and the further high integration of them will be attained from the above-mentioned magnetic memory apparatus.

[0089] As mentioned above, since the effect of an anti-field by the magnetic pole of each both ends of the 1st and the 2nd a little more than magnetic layer of a magnetic memory cell can be reduced certainly, while being able to hold the magnetization condition stabilized even if the arrangement pattern of a magnetic memory cell was made detailed according to the above-mentioned magnetic memory apparatus, it becomes possible to realize the magnetic memory apparatus which has a higher degree of integration. Moreover, since the 2nd a little more than magnetic layer used as a memory layer forms the closed magnetic circuit with the closed magnetic circuit layer, the 2nd a little more than magnetic layer does so collectively the effectiveness that it is also possible to reduce the power consumption of the magnetic memory apparatus which used many such magnetic memory cells while serving as stability to an external leakage field.

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[Translation done.]

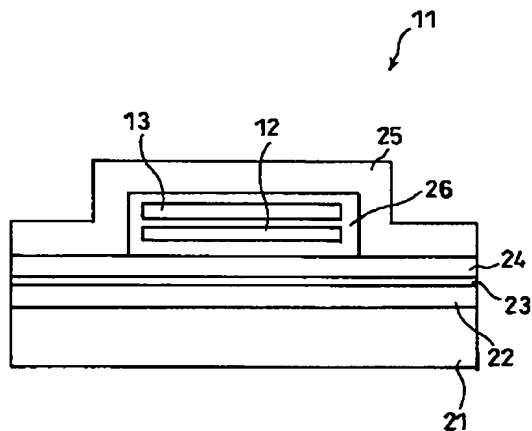
## \* NOTICES \*

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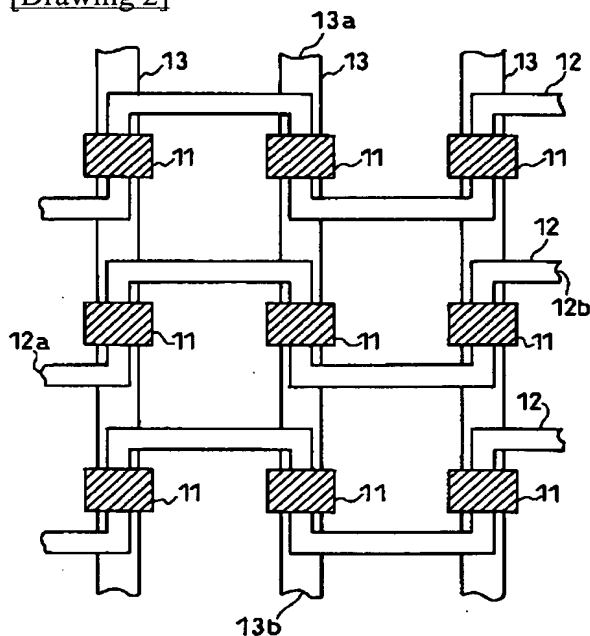
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DRAWINGS

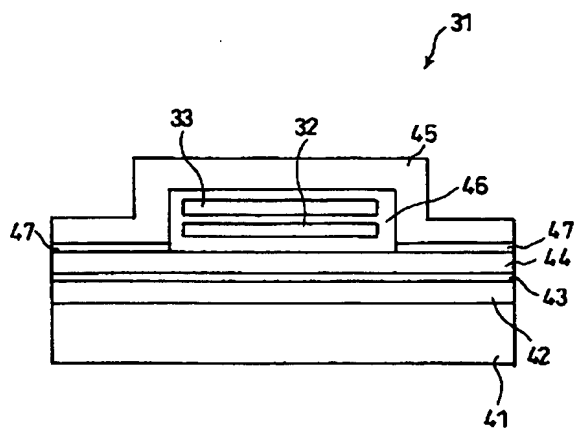
[Drawing 1]



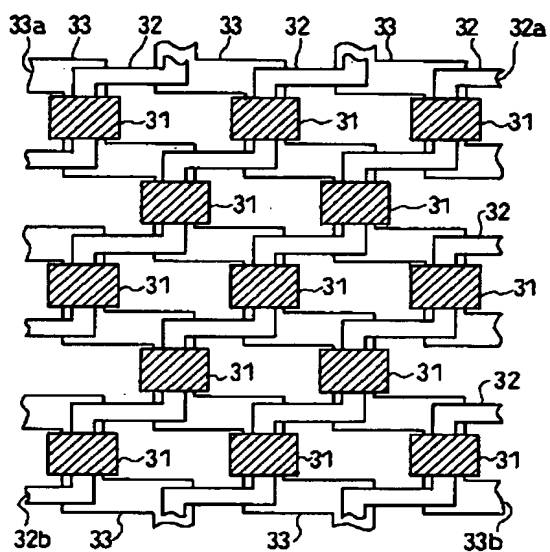
[Drawing 2]



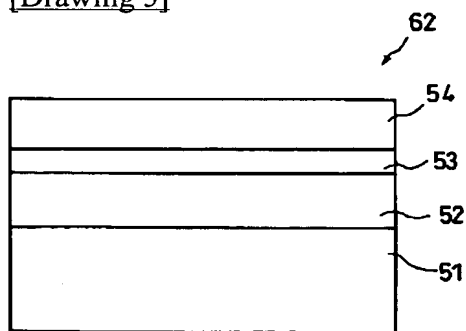
[Drawing 3]



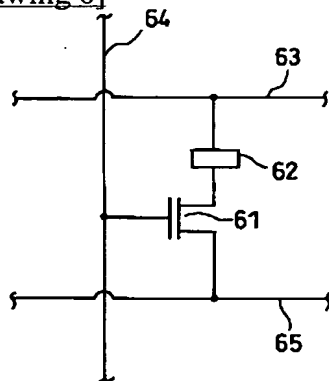
[Drawing 4]



[Drawing 5]



[Drawing 6]



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[Translation done.]